Reinventing the wheel: parabolic flight validation of reaction spheres

Problem Statement

- Conventional ACS may not be adequate for demanding spaceflight missions with fine pointing requirements or those exposed to large disturbance torques.
- Low-SWaP reaction spheres will improve the ACS performance for a wide range of smallsat missions and may provide higher reliability
- Reaction spheres are sensitive to preloads and cannot be adequately characterized in normal-g; therefore we require a zero-g environment
- This technology is cross-cutting across GSFC lines of business, and is endorsed by the Univ. of MD and MIT

Tech Development Team

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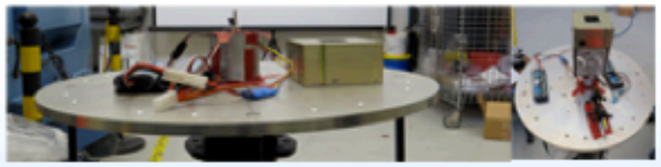
- The complete team comprises of GSFC Engineers: Allison Willingham, Matt Colvin, Paul Mason, Andrew Salomon. NGC Engineers: Tony Granados, Mike Stoddard, Larry Linton



New ACS testing facility. Other equipment available at both Goddard and NGC

Proposed Flight Experiment

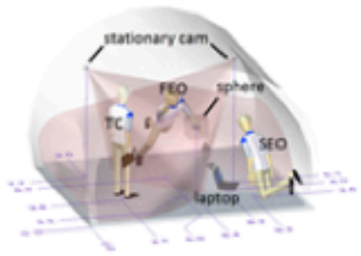
Experiment Readiness:

- Prototype optimization: 02/2014, Setup new ACS test bench:03/2014, Payload adaptation, TEDP: 03/2014, Functional testing: 04/2014, Thermal cycling: 05/2014, Vibration loading: 06/2014, Thermal vacuum testing: 07/2014, Parabolic flights: 08/2014

Test Vehicles:

- We propose 4 test configurations, 5 trials each, with >12 seconds of zero-g per trial on 3 parabolic flights

Test Environment:

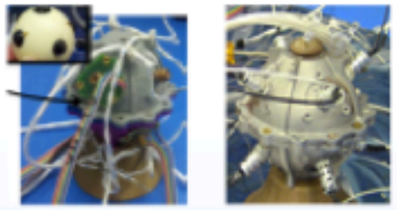


- Location of test personnel and payloads in parabolic flight. The laptop and stationary cameras are secured throughout the flight. A 10x10 ft^2 section of the flight vehicle will be required

Test Apparatus Description:

- Control system is based on a spherical rotor embedded with cylindrical permanent magnets. For every pole, there is one on the opposite side. Four pairs of electromagnets are pulsed to pull the permanent magnets on the rotor. These magnets pass through a pattern of hall effect sensors that are used for feedback control.

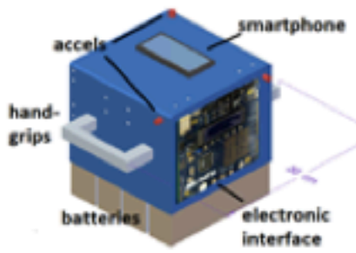
C1 containment: a low friction, spring-loaded DLC hard contact.



C2 containment: a ferrofluid bearing system

Technology Maturation

- The current status of technology maturation is extremely favorable since basic feasibility has been demonstrated. The control system is robust and has been submitted by NGC for a patent
- Entry TRL 4 at time of proposal submission. After a suite of environmental tests, sphere technology will be approx TRL 5 before parabolic flights. Exit TRL 6 after parabolic flights.
- Beyond parabolic flights, we will pursue ISS demonstration and finally, CubeSats. The ultimate vision is the widespread integration of spheres tech on smallsats.



Depiction of free-flying payload: includes redundant onboard sensors & complimentary external sensors

Experiment Objectives

- The proposed goal is to use zero-gravity flights for (1) functional validation; (2) torque, momentum, accuracy, & stability characterization of two versions of NASA/NGC reaction sphere prototypes.
- Data will be used to downselect from two sphere prototypes and to calculate friction losses needed for further optimization

Submitted by Alvin Yew, NASA GSFC
Penta-Chart for AFO8 01/16/2014